Using Integrated Synthetic Environments To Train The Command And Control Of Military Assistance To Civil Emergencies

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Summary

A research programme has been initiated to develop an integrated SE for training the Command and Control of civil emergencies. The focus for this work is on the UK Military Assistance to the Civil Authority (MACA) activities. Events such as the fuel crisis, strikes by fire and ambulance services, and the increasing demands generated following the World Trade Centre attack, have all required the deployment of MoD assets. The SE research community in the UK has long wished to see its applications migrate from military use to the civil domain. Therefore this study seeks to identify where existing SE tools and techniques can be used to support military aid to civil authorities.

This paper discusses the research programme, sponsored by the UK MoD Corporate Research Programme (SSS Domain) and describes the work carried out to date. Research conducted so far includes a stakeholder analysis of recent national crises. This analysis led to a generic model of crisis development, which identifies five phases ranging from prevention through containment to a review phase at the end. The application of SEs to support these phases is then described. In parallel to the stakeholder analysis, a survey of simulation tools that have the potential to support crisis management was performed and is described here. Finally some prototype architectures are illustrated and an overview of future work in this programme is discussed.

1. Introduction

The UK MoD Synthetic Environment Co-ordination Office (SECO) have long had the desire to see the research in synthetic environments migrate from the applied military research domain to other key areas. The rise in concern over terrorist attack since 9/11 and civil emergency situations in recent years increased the desire for a research programme to support the MOD department of state function. The current programme "Using Synthetic Environments (SEs) for Department of State Activities", MOD reference 20483, was therefore initiated. The focus of this study is to provide an integrated SE to support scenarios where the armed services are required to contain civil emergencies. In the UK military support to civil emergencies falls under the term Military Aid to the Civil Authorities (MACA). MACA is a catchall term that includes the following acronyms:

- MACP - Military Assistance to the Civil Power (e.g. troops deployed in Northern Ireland);
- MACC - Military Assistance to the Civil Community (e.g. flooding);
- MAGD - Military Assistance to Government Departments (e.g. petrol crisis).

This is a two year programme which in the first year seeks to understand the MACA domain, identify relevant stakeholders and assess the applicability of SEs to support MACA operations. In the second year the programme is focused on developing a prototype architecture to integrate SE modelling tools which can support MACA.

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What do we mean by SE?

The study seeks to utilise the wide range of Synthetic Environment knowledge and technology that has been produced in the last decade of research and development to support military applications. A number of definitions have been put forward to describe what an SE is, including the SECO definition[1] - *"A computer-based representation of the real world, usually a current or future battle space, within which any combination of 'players' may interact. The players may be computer models, simulations, people or instrumented real equipments"*. Therefore, throughout the course of this paper the term SE takes a very broad description. Modelling data in the live, virtual and constructive domains are included in this definition as well as electronic conversions of data held in more traditional spreadsheet and tabular formats.

2. Stakeholder analysis

Conducting an analysis of published inquiries[2,3,4,5] and interviews with stakeholders enabled us to understand the range and scope of the agencies and organisations involved in civil emergencies. The diversity of stakeholders and the related information that they require, or may generate, reinforces the potential complexity of the data a SE based crisis management tool needs to integrate.   A number of case studies taken from recent UK crises that fall into the MACA category have been studied. The case studies enabled the identification of stakeholders, information needs and potential crisis monitoring metrics. The three case studies chosen were the foot and mouth outbreak 2001, the petrol crisis 2000 and the fire fighters strike 2002/3. A brief overview of each crisis follows.

Case Study 1. Foot & Mouth 2001

The first case of foot and mouth was confirmed on 20th February 2001. On the 9th March the lead government agency the Ministry of Agriculture Fisheries and Food (MAFF) formerly requested assistance from the Royal Army Veterinary Corps and other MOD assets to assist in the planning and logistics aspects of combating the disease. The disease was finally eradicated by the end of September 2001. Over 100 agencies and pressure groups were involved throughout the course of the crisis.

Epidemiological models were used during the crisis to predict the spread of the disease and in turn assist the development of the management strategy. This strategy transitioned into an aggressive culling policy that resulted in the slaughter of over 4 million animals for disease control purposes. The number of confirmed cases per day provided a clear metric of crisis evolution.

Case Study 2. Petrol Crisis 2000

The petrol crisis occurred for one week in September 2000 and briefly again in November. Driven by the increasing costs of petrol in the UK the newly formed Farmers For Action (FFA) pressure group led a series of blockades targeted at oil refineries. The petrol shortage at filling stations was exacerbated by panic buying from the public. Initial public support faded once the health service began suffering and occupational health workers were affected. The military were on hand to drive tanker trucks if required however. The FFA called off the blockades with a 60 day warning of repeat action if no concessions on fuel prices were made. Due to minor concessions by the Chancellor and memories of the last few days of the September crisis, the repeat action did not receive sufficient support and the crisis failed to materialise.

Although no military involvement was required SEs could have been used to support the planning and management of the petrol crisis. Models of the critical communications infrastructure (road and rail) with an overlay showing refinery locations and fuel stocks would provide a useful visualisation of the crisis unfolding.

Clear performance metrics for this crisis were fuel station stocks and potentially peak time queues at filling stations.

Case Study 3. Fire Fighters Strike 2002/3

When pay negotiations between the Fire Brigades Union (FBU) and local authorities broke down, a series of strikes by fire fighters was initiated. The Office of the Deputy Prime Minister requested assistance from the MOD to provide emergency cover to contain the crisis. The first strike was scheduled for 29th October giving the armed forces approximately two months to prepare and train the fire fighter crews to use specialist equipment such as the green goddess pump (a 4 wheel drive fire engine designed in the 1950s). Joint command centres were established in local police force headquarters and staffed by senior police, fire and armed forces personnel. The role of the command centre was to filter the emergency calls and dispatch appropriate resources. Typically this took the form of initial on-site inspection by police vehicles followed by military fire fighting vehicles if the incident posed a threat to human life. The use of these joint command centres was seen as a success and indicates that a combined command centre (potentially augmented by SE visualisation) would be beneficial in general crisis management. The first strike actually occurred on November 13th for 48 hours with further strikes in November, January and February.

The fire fighters strike produced two key training requirements on military personnel. The first was just in time training of specialist equipment and vehicle training for handling the green goddess vehicle. The second was joint command team training between military and civil officers. Using SEs to support command team training in the military domain is well established. Modifying these training systems to reflect the joint resource management aspects of this strike is achievable. The time to respond to fire incidents would provide a useful metric of the effectiveness of the emergency cover and could be captured easily in both real world and simulated domains.

The studies into the three historical crises in which MACA was applied or was ready to be applied, led to two outcomes: a model of crisis development, and a rich picture of a generic MACA crisis[6].

3. Model of Crisis Development

A model of crisis development can be used to quantify the varying role of agencies compared to stages of crisis and enable emergency planners to switch resources proactively. The model developed and shown in figure 1 identifies five key stages;

- **Prevention** - The objective is to stop a crisis occurring in the first place. This objective is achieved by gathering intelligence about emerging threats and taking preventative measures as appropriate.
- **Preparation** - Applying resources to stop a known crisis causing damage. This phase includes planning, training, stockpiling vaccines etc.
- **Containment** - remedial action to minimise the effects of a crisis event or damage limitation
- **Recovery** - restore conditions to normal after a crisis event and re-building after the damage caused by a event
- **Review**.- Lessons learned (does not always happen) which can be used to improve training
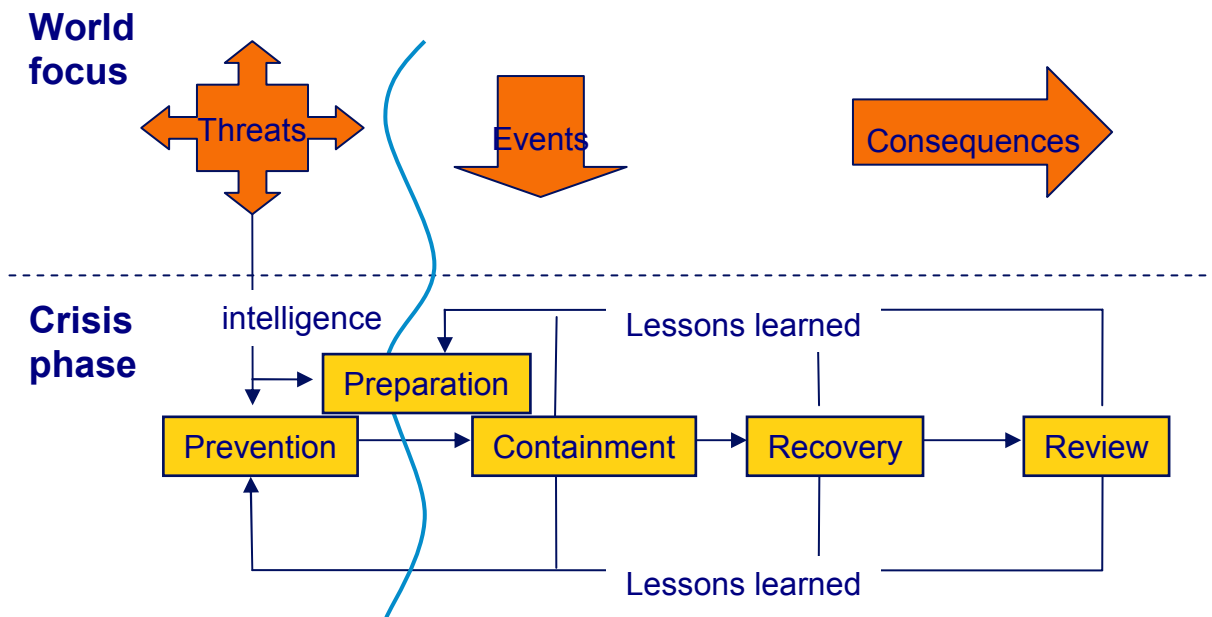
Figure 1. Model of crisis development

There is a degree of overlap between the prevention and preparation stages due to the uncertainty of when a threat transitions into a crisis event. One can imagine a use for SEs across all these phases from 'gaming' future crises in the prevention stage to an SE based AAR in the review stage providing enhanced visualisation of the evolution of an incident. It is important to develop a scalable solution and an open architecture in any developed system to customise the SE(s) to represent a specific crisis.

4. Crisis Metrics

To control a crisis and manage resources effectively it is helpful to understand where in the crisis model you are, at a point in time. A key to understanding what stage of a crisis you are in, is the capability to identify and monitor valid metrics. In foot and mouth outbreak the confirmed cases in the animal population was a clear metric. In other operations such as the return to normality in Kosovo following the conflict, the frequency of taxi use by the civilian population was another useful metric. Queue length at petrol stations and petrol station stocks may have been used as useful metrics during the petrol strike. Time to respond to a fire incident would have been a useful metric during the fire fighter's strike. This metric would measure how effective the emergency cover operated. To choose an appropriate metric one must consider a number of factors:
- The metric should be validated;
- More than one metric should be used where possible;
- Chosen metrics may not at first seem an obvious choice;
- Different metrics may be required for different stages of the crisis development.

Knowing the stage of a crisis is important because that awareness allows planners to switch resources proactively, thereby saving time & money. Figure 2 illustrates how a generic crisis metric may evolve over time superimposed over data from the foot and mouth outbreak. The data points reflect the number of confirmed cases per day recorded by the MAFF (now called the Department of Environment Food and Rural Affairs (DEFRA)).
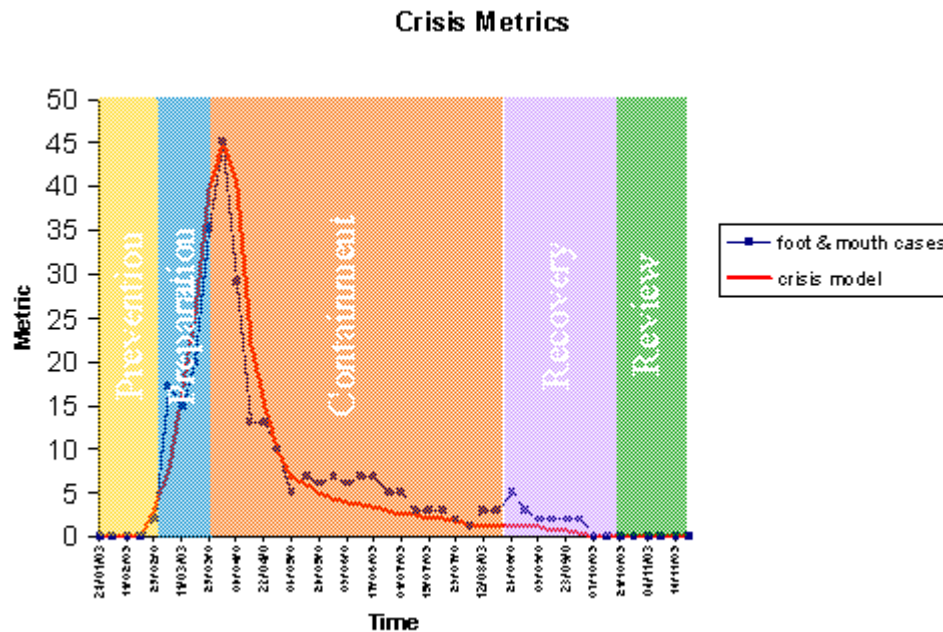
Figure 2 Generic crisis metric compared with foot and mouth cases per day

5. Application areas for SEs in Crisis Development

From the generic model of crisis development and the discussions on crisis metrics we can consider two main applications where SE's may usefully support the crisis management process.

- SE Command and Control Centre – use SEs to provide an aid to the decision making process through crisis monitoring and visualisation (applicable across all phases). This could either use live data feeds for management or be stimulated by a SE crisis simulation centre for training or operational analysis (OA).
- SE Crisis Simulation – an underpinning simulation to support both OA to test emergency measures (in the prevention phase) and training for crisis management (for the preparation phase).

SE Command and Control Centre

SE can be used to support the command and control of crises. The Command centre could be developed along military lines with external links to other key stakeholders and cells for the current operational picture, forward planning, media, police, fire army et cetera. SEs have been used to train military headquarters and unit commanders for some time. A logical progression is to extend this concept to train joint military and civil agencies (police, fire). Such a command centre would include the following key elements;

- Large screen display for shared situational awareness
- Closely coupled specialist cells
- Teaming with key resources (armed forces, police, fire)
- Scalable map display showing varying levels of resolution (e.g. vehicle to unit level aggregation).
- An underpinning architecture to integrate and convert heterogeneous data sources into an electronic representation.

The SE in the command centre would provide enhanced visualisation for command centre using 2/3D modelling and enable the visualisation of live assets. The integration of live assets into the constructive domain

has been demonstrated in previous UK MOD sponsored programmes using the BATS/DIS[1] interface. The aggregation and dis-aggregation of entities has been demonstrated under the Joint Intelligence Virtual Environment (JIVE)[7]. This capability would be useful in providing a scalable picture of deployed assets from the top-level aggregate view to a more detailed entity level view.

The SE command centre could also provide an After Action Review (AAR) facility. AAR is a formalised system of providing feedback to trainees to improve their skills. The use of AAR in military training is well established. AAR for civil crises are less well understood as they require the identification of additional metrics of command staff and emergency planner performance. Using a SE based AAR with objective performance metrics would provide a clear method to visualise emergency plans, their actions and associated consequences. Finally, lessons learned from the crisis can be used to update training scenario databases.

SE Crisis Planning / Training through Simulation

In order for SEs to support the prevention and preparation phases of a crisis, an underpinning simulation of the containment phase is required. This simulation would be used to stimulate the emergency planners and command and control staff for OA or training applications. Clearly a SE is of limited use as an aid to lifting sandbags to build flood defences or controlling a fire hose. However, there may be some benefit in developing computer based training (CBT) applications for specialist equipment training.

The established SE technology of a distributed environment would allow large scale training exercises to be developed including geographically dispersed agencies such as local authorities. Emergency planning officers in local authorities may be involved infrequently in a crisis but still have a role to play (e.g. authorising the release of sandbags for flood prevention). In some situations where these individuals could not participate in such an exercise, agent based software could be developed to take the roles of the additional stakeholders. A method for incorporating these infrequent stakeholders is required that does not impact on the smooth running of the crisis simulation.

Changes are required to existing SEs to accommodate the additional requirements of MACA scenarios. Civil assets need to be represented including police and fire vehicles and their associated communication systems. This includes representing the vehicle systems and the behaviours to perform simple tasks in SAF based systems. Containment models are also required such as the impact of sandbag banks on river flow or water hoses on building fires. In short much greater fidelity is required to link the impact of people and platforms to the environment.

In all crises the 'public' can have a great deal of influence in the recovery from an incident. Population models have a role at the incident itself through the generation of victims (displaced population, evacuations etc.) and at the highest strategic levels (response to a remedial course of action can have political consequences).

Additional uses of a crisis simulation system include;
- A test harness for metric evaluation or highlighting potential metrics.
- Hypothesis testing in the recovery phase. This could be to analyse the re-allocation of resources in order to restore conditions to normal faster.

6. Data requirements for SE systems to support Crisis Management

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[1] BATUS Asset Tracking System / DIS interface. This software takes live vehicle positions from an asset tracking system and converts the data into DIS packets, facilitating live/constructive interoperability.

Table 1 shows some data requirements drawn from the case studies and an additional case – flooding, compared to their implications for SE based monitoring of a live event and a simulated incident for training or OA.

Incident / Data Sources	Synthetic Environment	
	LIVE (monitor)	Simulation (Training / OA)
Fire Strike		
Vehicle locations	Asset tracking to DIS	Semi-Autonomous Force (SAF) models
Weather	Link to weather server	Simulate weather patterns (SAF systems)
Fire dispersion	Feedback from field	Model of fire dispersion
Chemical data (risk assessment)	view hazards, handling procedures	Simulate chemical fires
Road usage	Live update from traffic associations (AA, RAC)	Traffic Simulation on city wide scale
Road network	Update from councils for road closures	Refine simulation with obstacles
Hospital locations	Map overlay for nearest location	Add features to database
Foot & Mouth		
Epidemiological model	Visualise algorithm	Implement algorithm in simulation
Foot & mouth cases	Live update from field	Use algorithm for dispersion simulation
No of VETS / military vet service?	Display resource as table	Computer generated vets?
Petrol Crisis		
Fuel supplies	Update from field	Logistics simulation
Road network	Rolling road block protesters	Simulate communications (road and rail) infrastructure
Refinery locations	Map overlay	Add features to database
Flooding		
River capacity / water table / Rainfall	Tabular data converted to 2/3D maps	Need model with high resolution (~inch resolution in height)
Tide information	Tables / Satellite / aerial images	3D simulation of flooding GIS based
Demographic data (population at risk)	Represent as GIS layer	Advanced population models for evacuation planning

Table 1. Data requirements mapped to their implications for SE use.

There are a number of common key data requirements that it can be assumed would be required by any SE system that might support crisis management.

These include:
- Scalable map data from large area rural to city and town maps;
- Maps of special services such as underground, rail and air corridors;

- Mapping of utilities (gas and electricity);
- Vehicle model data;
- Time dependant data such as disease spread, traffic flows, crowd behaviours;
- Meteorological data;
- Traffic and population movement models.

These components indicate a number of discrete tools that will form part of the crisis simulation architecture.

7. Crisis simulation architecture

The review of case study material approach was used to develop the rich picture of a crisis incident (figure 3). This picture highlights the complex organisational structures and data flows at work during a crisis event. This complex picture indicates the requirements for a SE to incorporate heterogeneous data sources in any potential system for crisis management.
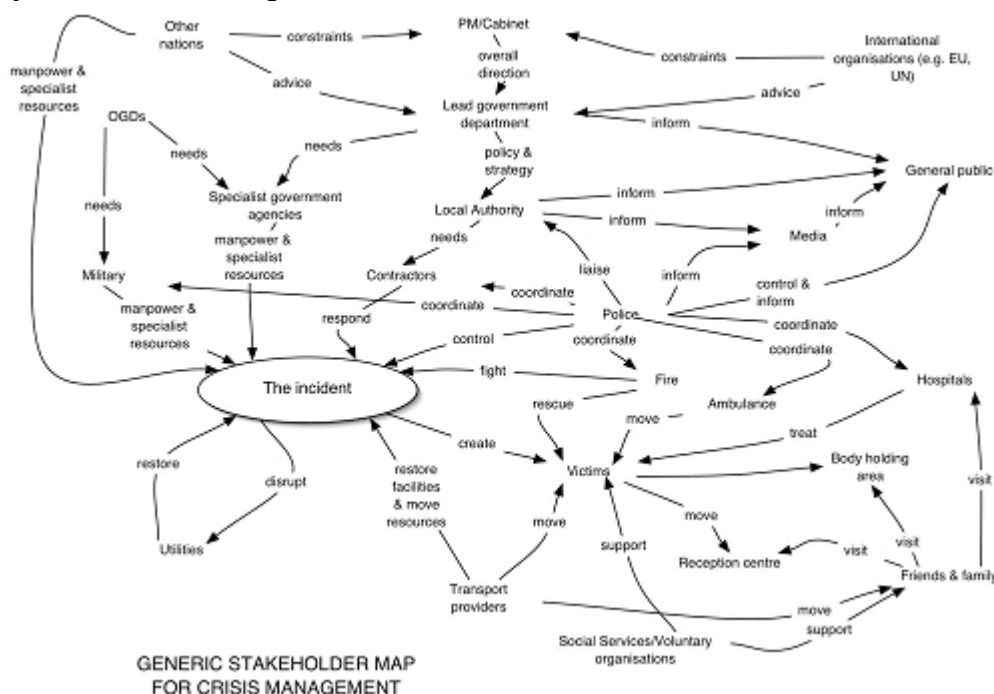

GENERIC STAKEHOLDER MAP
FOR CRISIS MANAGEMENT

Figure 3. Rich Picture of a generic incident

Survey of Potential Tools

At the start of this research programme a number of tools were known to the authors that were applicable to crisis management. Therefore, rather than design an integrated SE for crisis management from the ground up it was decided to re-use current simulation applications where possible. A search has been undertaken to identify SE applications that can be re-used in a larger SE for crisis management. Due to the diversity of MACA scenarios the search encompassed a wide range of application areas. The search highlighted approximately 60 applications with the potential to support a MACA SE. These range from CGF applications, familiar to the military community, virtual trainers for first responders and simulations of natural phenomena such as flooding. Examples include ATLAS Ops (a police force command & control tool) Diablo VR (a first responder trainer) ANFAS (a GIS based flood analysis tool).

An issue with these applications is the ease with which they can be networked to play in the same environment

and the modifications required to support MACA scenarios. Modifications would include introducing the dynamics of civil assets and the "weapons" systems i.e. how to simulate a fire hose and the dynamics of containing a fire. Some scenarios may require simulations of large numbers of civilians. Successful applications of this kind have been demonstrated at QinetiQ using fluid dynamics to represent the population and a DIS interface to allow for interoperability.

If a SE is constructed to simulate the vast range of MACA scenarios, a composable architecture is required which can be tailored for a specific incident. This "golf bag" approach is needed so tools can be selected and plugged into a system architecture to provide the underpinning simulation. Figure 4 displays a hierarchical concept where simulation tools comprise HLA federations at three levels (Tactical, Operational and Strategic). These levels represent the management levels that operate during civil crises. This architecture arises from the rich picture of a generic incident and the stakeholder analysis carried out previously. Each level is a federation in its own right. Communication between levels is facilitated by an HLA gateway. This approach would allow close coupling between the components that constitute the simulated incident. Additional players at a higher level could take part in the simulation through the gateways. For example the local authority planning officer could dial into the simulation through a secure server to participate infrequently through the course of the exercise.
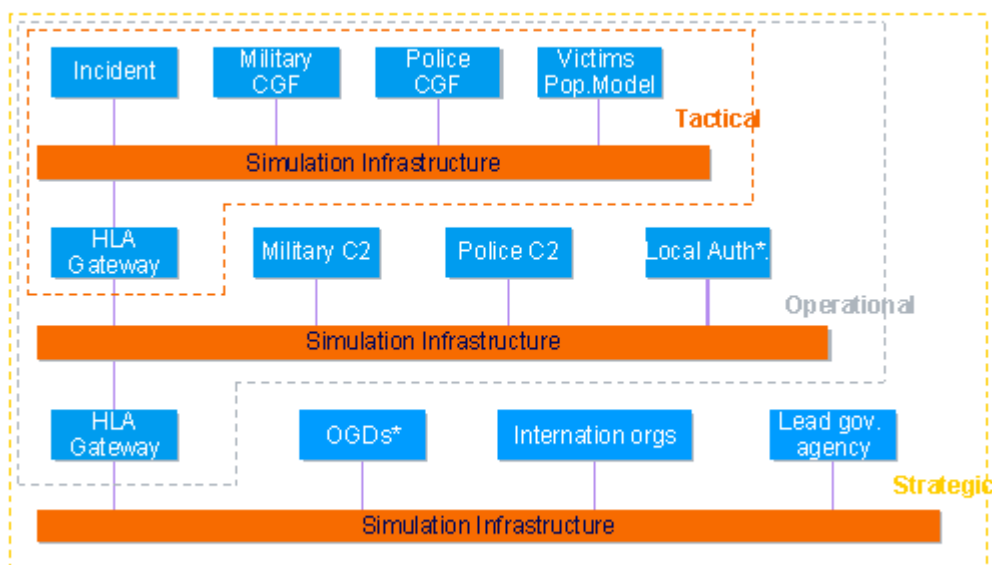

Figure 4 Hierarchical simulation architecture

* Local Auth. = local authorities, OGD = Other Government Departments.

8. Future Work

The hierarchical simulation architecture represents the first pass at a simulation concept. The next stages of this programme will develop the SE command centre and crisis simulation concepts further. A number of scenarios will then be developed to focus research in the second phase of the programme. A shortlist of tools will then be selected to represent the required components of the crisis simulation system. It is anticipated that

this crisis simulation will be used to stimulate a demonstration of the SE based command and control centre to MoD and Other Government Departments.

9. Acknowledgements

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